



United States Department of the Interior

U.S. GEOLOGICAL SURVEY

Reston, Virginia 20192

REPORT OF CALIBRATION of Aerial Mapping Camera

June 12, 2000

Camera type: Zeiss RMK Top 15*
 Lens type: Zeiss Pleogon A3/4
 Nominal focal length: 153 mm

Camera serial no.: 145860
 Lens serial no.: 145905
 Maximum aperture: f/4
 Test aperture: f/4

Submitted by: Kucera International
 Willoughby, Ohio

Reference: Kucera International purchase order
 No. 00-0124BJ, dated June 9, 2000.

These measurements were made on Kodak Micro-flat glass plates, 0.25 inch thick, with spectroscopic emulsion type 157-01 Panchromatic, developed in D-19 at 68° F for 3 minutes with continuous agitation. These photographic plates were exposed on a multicollimator camera calibrator using a white light source rated at approximately 5200K.

I. Calibrated Focal Length: 152.493 mm

II. Lens Distortion

Field angle:	7.5°	15°	22.7°	30°	35°	40°
Symmetric radial (um)	-1	-3	-3	-2	-1	3
Decentering (um)	0	0	1	1	2	3

Symmetric radial distortion parameters

$$\begin{aligned} K_0 &= 0.7370 \times 10^{-4} \\ K_1 &= -0.6281 \times 10^{-8} \\ K_2 &= 0.2307 \times 10^{-13} \\ K_3 &= 0.0000 \\ K_4 &= 0.0000 \end{aligned}$$

Decentering distortion parameters

$$\begin{aligned} P_1 &= -0.1685 \times 10^{-6} \\ P_2 &= 0.9491 \times 10^{-7} \\ P_3 &= 0.0000 \\ P_4 &= 0.0000 \end{aligned}$$

Calibrated principal point

$$\begin{aligned} x_p &= 0.003 \text{ mm} \\ y_p &= 0.000 \text{ mm} \end{aligned}$$

The values and parameters for Calibrated Focal Length (CFL), Symmetric Radial Distortion (K_0, K_1, K_2, K_3, K_4), Decentering Distortion (P_1, P_2, P_3, P_4), and Calibrated Principal Point [point of symmetry] (x_p, y_p) were determined through a least-squares Simultaneous Multiframe Analytical Calibration (SMAC) adjustment. The x and y-coordinate measurements utilized in the adjustment of the above parameters have a standard deviation (σ) of ± 3 microns.

* Equipped with Forward Motion Compensation

III. Lens Resolving Power in cycles/mm

Area-weighted average resolution: 101

Field angle:	0°	7.5°	15°	22.7°	30°	35°	40°
Radial Lines	113	134	113	113	113	95	95
Tangential lines	113	113	113	113	95	80	80

The resolving power is obtained by photographing a series of test bars and examining the resultant image with appropriate magnification to find the spatial frequency of the finest pattern in which the bars can be counted with reasonable confidence. The series of patterns has spatial frequencies from 5 to 268 cycles/mm in a geometric series having a ratio of the 4th root of 2. Radial lines are parallel to a radius from the center of the field, and tangential lines are perpendicular to a radius.

IV. Filter Parallelism

The two surfaces of the USGS TOP 15 test filter KL-F (60%) No. 142399 and the KL-F (36%) No. 148619 filter are within 10 seconds of being parallel. The USGS filter, in conjunction with the internal "B" filter, was used for the calibration.

V. Shutter Calibration

Indicated time (sec)	Rise time (μ sec)	Fall Time (μ sec)	$\frac{1}{2}$ width time (ms)	Nom. Speed (sec.)	Efficiency (%)
1/100	3741	3549	10.74	1/120	76
1/200	1954	1920	5.10	1/260	76
1/300	1638	1642	3.59	1/340	76
1/400	944	951	2.58	1/500	76
1/500	734	747	2.04	1/630	76

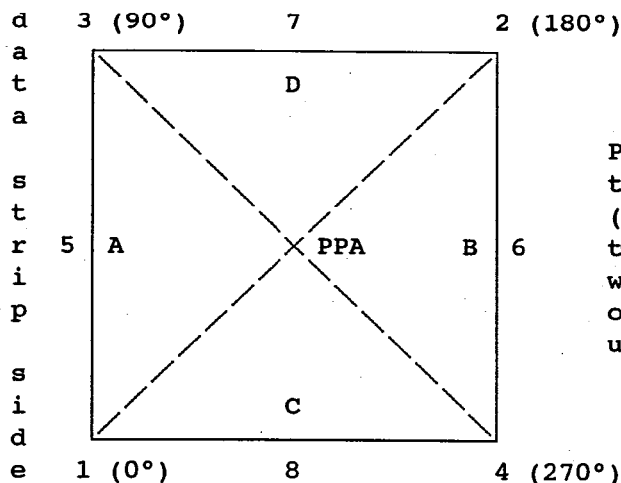
The effective exposure times were determined with the lens at aperture f/4. The method is considered accurate within 3 percent. The technique used is Method I described in American National Standard PH3.48-1972(R1978).

VI. Magazine Platen

The platens mounted in FK 24/120 film magazine No. 127615 and T-MC film magazine No. 147467 do not depart from a true plane by more than 13 μ m (0.0005 in).

The platens for these film magazines are equipped with identification markers that will register "CZ186" for magazine No. 127615, and "148028" for magazine No. 147467 in the data strip area for each exposure.

VII. Principal Points and Fiducial Coordinates



Positions of all points are referenced to the principal point of autocollimation (PPA) as origin. The diagram indicates the orientation of the reference points when the camera is viewed from the back, or a contact positive with the emulsion up. The data strip is to the left.

	<u>X coordinate</u>	<u>Y coordinate</u>
Indicated principal point, corner fiducials	-0.007 mm	0.009 mm
Indicated principal point, midside fiducials	-0.004	0.005
Principal point of autocollimation (PPA)	0.0	0.0
Calibrated principal point (pt. of sym.) x_p, y_p	0.003	0.000

Fiducial Marks

1	-113.001 mm	-112.992 mm
2	112.984	113.008
3	-113.014	113.002
4	113.009	-112.992
5	-113.006	0.002
6	113.005	0.008
7	-0.011	113.014
8	0.003	-113.007

VIII. Distances Between Fiducial Marks

Corner fiducials (diagonals)

1-2: 319.602 mm 3-4: 319.624 mm

Lines joining these markers intersect at an angle of 90° 00' 06"

Midside fiducials

5-6: 226.011 mm 7-8: 226.021 mm

Lines joining these markers intersect at an angle of 90° 00' 07"

Corner fiducials (perimeter)

1-3: 225.994 mm 2-3: 225.997 mm

1-4: 226.010 mm 2-4: 226.001 mm

The method of measuring these distances is considered accurate within 0.003 mm

Note: For GPS applications, the nominal entrance pupil distance from the focal plane is 254 mm with a 10 mm filter thickness. Additional filter thickness will increase entrance pupil distance by 0.34 X added thickness.

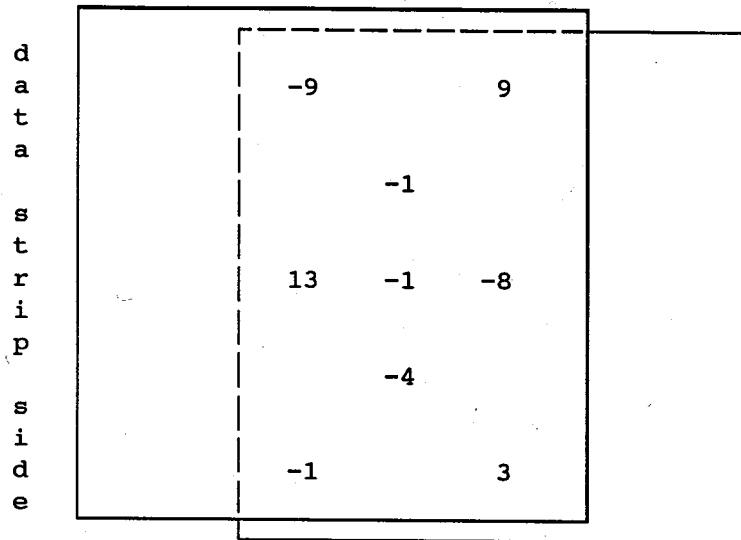
IX. Stereomodel Flatness

FMC Magazine No.: 127615

Base/Height ratio: 0.6

Platen ID: CZ186

Maximum angle of field tested: 40°



Stereomodel
Test point array
(values in micrometers)

The values shown on the diagram are the average departures from flatness (at negative scale) for two computer-simulated stereo models. The values are based on comparator measurements on contact glass (Kodak Micro-flat) diapositives made from Kodak 2405 film exposures. These measurements can vary by as much as $\pm 5 \mu\text{m}$ from model to model.

X. System Resolving Power on film in cycles/mm

Area-weighted average resolution: 51

Film: Type 2405

Field angle:	0°	7.5°	15°	22.7°	30°	35°	40°
Radial Lines	57	57	57	57	57	48	48
Tangential lines	57	57	48	57	48	48	40

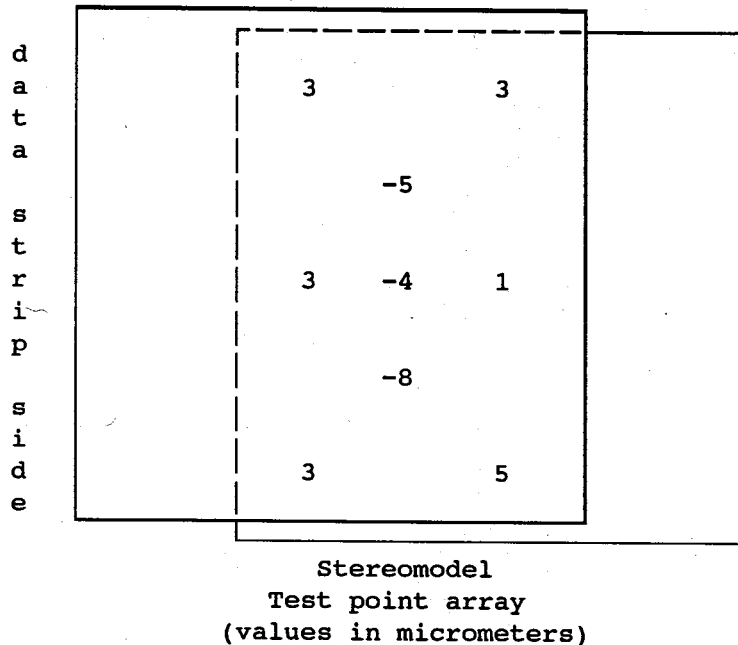
IX. Stereomodel Flatness

FMC Magazine No.: 147467

Base/Height ratio: 0.6

Platen ID: 148028

Maximum angle of field tested: 40°



The values shown on the diagram are the average departures from flatness (at negative scale) for two computer-simulated stereo models. The values are based on comparator measurements on contact glass (Kodak Micro-flat) diapositives made from Kodak 2405 film exposures. These measurements can vary by as much as $\pm 5 \mu\text{m}$ from model to model.

X. Lens/Film Resolving Power in cycles/mm

Area-weighted average resolution: 52

Film: Type 2405

Field angle:	0°	7.5°	15°	22.7°	30°	35°	40°
Radial Lines	57	57	57	57	57	48	48
Tangential lines	57	57	57	57	48	48	40

This aerial mapping camera calibration report supersedes the previously issued USGS Report No. OSL/2317, dated May 5, 1997.

Frank C. Maccue

Frank C. Maccue
Chief, Optical Science Laboratory
National Mapping Division